THE COLOR SENSE TESTER.

BY

E. W. SCRIPTURE, PH.D. (LEIPZIG),
Director of the Psychological Laboratory,
Yale University.

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PRINCIPLES OF THE COLOR SENSE TESTER.

The fundamental requirement for a test of color vision is that of *reliability*; the test must with absolute certainty exclude all forms of color defect that would interfere with service on the railway and on shipboard, and must not exclude persons who do not possess such defects.

This requirement is not met by the wool test. In the first place there are many cases of rejection for color blindness which later examination proves to have been unjustified. There are also many cases of color blindness discovered after the person has passed the test; these are regularly treated as cases of "acquired" color blindness without the certainty that they are not sometimes cases of overlooked color blindness.

On the other hand, railway and marine surgeons who use a test with colored glasses in addition to the wool test, constantly report the discovery of cases by the one form of test which have successfully passed the other one. This would indicate that neither the wool test nor the usual test with colored glasses is reliable.

The first principle to be adopted for a test is that of the closest possible *resemblance to the actual conditions* under which lights are to be judged. In practice a railway man or a pilot is required to decide for himself which of the lights he sees are red, green and white. An ideal test would consist of an immense number of such lights under all the variations of brightness, distance, fog, etc. Any concrete test should consist in the reduction of this ideal to a convenient form.

The usual wool test fails in respect to this principle. In practice the railway man or pilot is never required to put into a pile all the objects that resemble a certain sample.

The second principle is derived directly from the first one: the objects used in the test should *resemble the objects* in actual practice. Colored lights would conform to this principle.

A third principle may likewise be deduced from the first one: the person tested should be required to *name the objects*. This is just what he

does in thinking about the lights he sees when at work ; he decides that this one is "red," that one is "green," etc.

The judgment of the likeness or unlikeness of colored objects is an utterly different matter and involves a different form of mental activity. Great trouble and uncertainty arise in the wool test because it demands a different form of judgment from that to which the men have been accustomed.

These three principles are satisfied with more or less success by the instruments of DONDERS, ELDRIDGE-GREEN, WILLIAMS and others who have devised arrangements for showing colored glasses.

A fourth principle may also be deduced from the first one : several colors should be *presented simultaneously* for comparison. In practice the person sees several lights together ; he compares them and decides on their colors. The secret of the past success of the HOLMGREN test over the tests of the DONDERS form lies in its use of the principle of comparison. The ideal test would combine this principle with the other three in which the HOLMGREN test fails.

I believe that I have succeeded in doing this in my color sense tester first described in 1895.

The color sense tester as first devised[1] has remained practically unchanged to the present day. The principles on which it is based were first published in outline in 1899 ;[2] the foregoing account summarizes them briefly.

DESCRIPTION OF THE COLOR SENSE TESTER.

In general appearance the color sense tester resembles an ophthalmoscope. On the side toward the person tested, Fig. 1, there are three windows of glass 1 cm. in diameter, numbered 1, 2 and 3 respectively. The opposite side of the tester, Fig. 2, consists of a movable disk carrying twelve glasses of different colors. As this disk is turned by the finger of the operator the various colors appear behind the three windows. At each movement of the disk the subject calls off the colors seen at the windows. Number 1 carries a very dark smoked glass ; all colors seen through it will be dark. Number 2 carries a piece of clear glass, showing all colors in full brightness. Number 3 carries a light smoked glass. There are thus thirty-six possible combinations of the colors. The twelve glasses are, however, reds, greens and grays.

[1] SCRIPTURE, *Some new apparatus*, Stud. Yale Psych. Lab., 1895 III 103.

[2] SCRIPTURE, *Color blindness and its tests*, Proceedings of the N. Y. Railway Club, Nov. 16, 1899.

A suitable arrangement of the colors gives direct simultaneous comparisons of reds, greens and grays of different shades. The well-known confusion by color-defectives of dark greens with reds, greens with gray, etc., are exactly imitated, and the instrument gives a decisive test for color-blindness. A peculiar advantage, however, lies in the fact that it presents reds, greens and grays simultaneously in a large number of different shades of intensity. The light of a green lantern, as it appears to

FIG. 1.

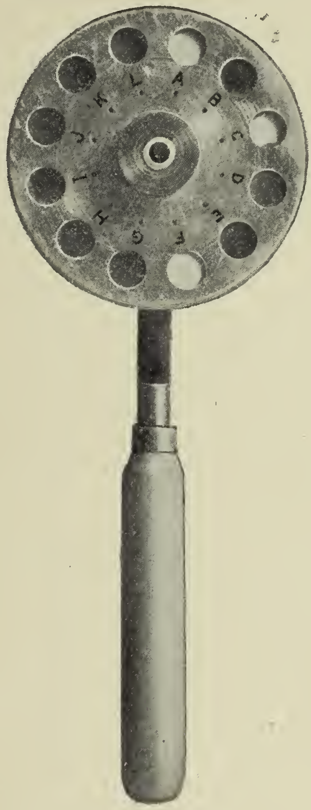

FIG. 2.

a color defective at different distances, is simulated by the red behind the darker gray; at the same time a white light is also changed. The color defective to whom weak green is the same as gray (white at a distance) is confused and thinks that the weakened green is gray (white) and the dark gray is green.

The actual test is performed in the following manner. The tester is held before a window or a white surface, but not in the bright sunlight, at about 5 meters from the person tested. The operator begins with any

chance position of the glasses, and asks the person tested to tell the colors seen through the three glasses, numbers 1, 2 and 3. He answers, for example, "number 1 is dark red; number 2 is gray; number 3 is green." The operator records from the back of the tester the letters indicating what glasses were actually used. Suppose he finds that A, D and G were opposite the glasses numbered 1, 2 and 3, he records: A_1, dark red; D_2, gray; G_3, green. The disk is then turned to some other position, the colors are again named, and the operator records the names used. For example, the result might be: "number 1 is dark green; number 2 is white; number 3 is red"; and the record would read: G_1, dark green; J_2, white; A_3, red. Still another record might give: J_1, dark gray; A_2, red; D_3, medium gray. Similar records are made for all combinations. Of course, the person tested knows nothing concerning the records made.

The records can be taken by anyone, and, on the supposition that the record has been honestly obtained and that the instrument has not been tampered with after leaving the central office, the comparison is likewise mechanical. There is none of the skillful manipulation required in the wool test and none of the uncertainty attaching to its results. The only instruction given to the subject is "Name the colors"; the results render the decision with mechanical certainty.

The requirements of simplicity and portability have, I hope, been successfully met; at the same time the instrument is thoroughly scientific in its principles.

Three colors at a time make a number agreeable to the subject; more would probably distract him. It is a fact well established by experimental psychology that under ordinary circumstances the mind cannot well attend to more than five objects at a time; the number 3 is within the limit.

The kind of comparison required is exactly the kind demanded in practice. The pilot, for example, is never required to decide if one color is "like" another, but to decide which colors are red, which green and which white. The HOLMGREN test requiring a judgment of "likeness" or "unlikeness" forces the subject to go through a difficult and complicated mental process. With the color sense tester the subject, seeing three colors at a time, passes judgment as to what colors they are.

The slide shown in Fig. 3 renders it possible to carry out tests quantitatively after the method proposed by DONDERS. The slide contains holes with the diameters of 1, 2, 3, 4, 5, 6, 7, 8 ^{mm} respectively. Using a standard source of illumination and placing the person tested at a given distance, the examiner can determine the smallest opening with which a certain color, say red, can be distinguished. If the smallest opening as determined for the average person be R^{mm} and for the person tested r^{mm},

the sensitiveness can be said to be indicated by $S = \frac{r}{R}$. The other quantitative test can likewise be readily carried out; a standard opening, say 1^{mm} is selected and the person tested is made to approach the instrument until he can distinguish the color. If D^{mm} is the average distance found and d^{mm} that for the person tested, his sensitiveness can be indicated by $E = \frac{d}{D}$.

Cases of color defect of the central part of the eye only are generally due to the excessive use of tobacco, especially when combined with the abuse of alcohol. To detect these cases the slide (Fig. 3) is placed in

FIG. 3.

window number 2 of the tester, and the person is required to call off the colors seen through the opening of 1^{mm} or 2^{mm} while the examiner shows them in rapid succession. The rapid succession is needed to allow no time for the person to turn his eye sidewise so that the colors fall outside the center.

The tester can be carried readily in the pocket, and can be used wherever a light of medium intensity is available.

When portability is not desired, the tester can be used in front of a properly arranged lantern. The ordinary semaphore lantern may be readily adapted to the purpose as shown in Fig. 4 by putting a cap and a small support in front of the lens. I use a semaphore lantern containing a four-candle power incandescent lamp and a sheet of white glass. The tester is simply laid in the small projecting arm in front of the glass. The examiner can see the letters marked on the edge of the tester. This form of the test is highly convenient for a permanent station, as it is always ready with the correct light.

These testers are now in use in several places. One examiner writes that "the men examined say that this test is more like the signals they are used to seeing every day on the road, and is therefore fairer than to ask them to pick out a lot of delicately tinted pieces of yarn." Yet this same examiner relates that he has by means of the tester caught a number of men who slip through the wood test.

There remains the question: Is this test alone sufficient for full protection of the traveling public? A proper test should be absolutely reliable. The employment of several tests indicates that none of them is reliable. I believe that the color sense tester is thoroughly scientific in its

character and that it is reliable and decisive. Moreover, I have in my experience caught with it a number of men who had passed the wool test, and have never found one who passed the tester and yet

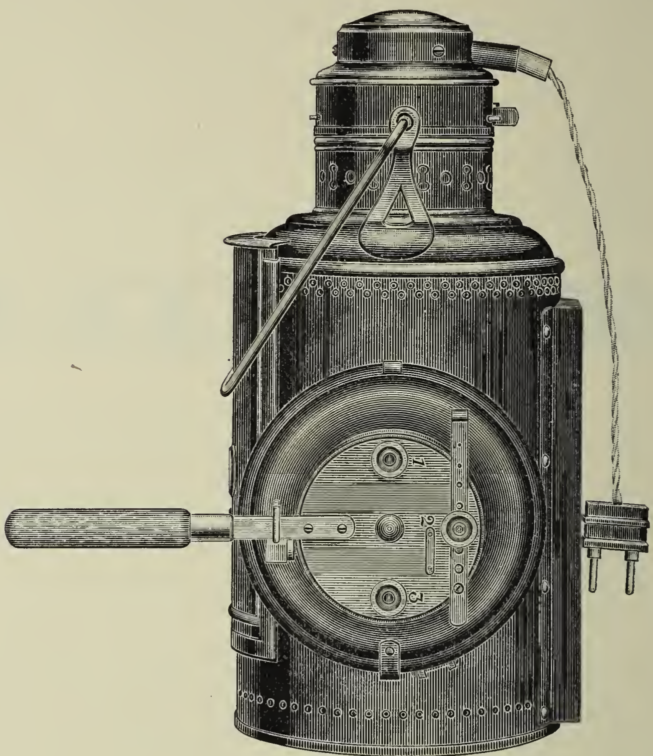

FIG. 4.

showed any indication of color blindness in any way. Still, this belief may not be shared by others, and for the present I would recommend using both tests. The final decision may be safely left to the results of practical experience.

INSTRUCTIONS FOR USING THE TESTER.

The tester is to be used in connection with the other tests for sharpness of vision, acuteness of hearing, etc. Every employee who may at any future time be required to use his sense of color should be tested on his entrance into the service. In case of defective color vision his rejection will occur whenever he attempts to enter branches of the service where such defectiveness is dangerous ; it is important that this should be understood by all at the start. The examination should be repeated at ntervals of not less than three years.

The following instructions are issued for the use of the examiner:

The eyes should be examined separately; a small blinder may, if desired, be hung over the eye not in use.

Hold the tester toward a bright surface (a window, the sky or the glass of a lantern) directly in front of the person to be examined, at a distance of five meters from his eye. The side with the three windows should be toward him. Ask him to call off the colors of these three windows in their order, beginning at the left window marked 1; thus, he is to say "Number 1 is such or such a color; number 2 is such or such a color; number 3 is such or such a color." You, the examiner, are then to notice the letters under the colored circles behind the three windows and to note the results on the record blank in the proper spaces. Thus, if he answers "Number 1 is red; number 2 is gray; number 3 is green," you look at the back of the tester and find, for example, that glass G is opposite number 1, D opposite number 2 and A opposite number 3. On the record blank you find a line containing in three blank spaces numbered G_1, D_2, A_3 and you write the answers in these places. While making the record you will have laid the tester down. You now turn the movable disc one or two or more notches either way; you hold the tester before the window and ask for answers as before. In this way you proceed until the record blank has been completely filled. A comparison of the answers with a list of the actual colors will at once reveal the defect if present. When color blindness is present, it is well to write the true colors in red ink in the same space with the answers of the person examined.

Occasionally it occurs that the person examined has a central defect of the field of vision which affects his perception of the object directly looked at if it is small. To detect this defect, place over the central window of the tester, the small cap having a minute hole and ask him to call off the colors as you turn the movable dise with considerable rapidity. The rapidity is advised in order to hinder the person from forming an opinion by using a side portion of the eye.

At the bottom of the blank the decision should be recorded as to the good or defective color sense of the person examined. No attempt should be made to state whether an existing defect is due to "red blindness" or "green blindness" or "color weakness," as such theoretical matters are still unsettled, the most common forms of color blindness being probably neither red nor green blindness. The question for you to decide is: Can this person distinguish and recognize with absolute certainty the lights used in practical service? The foregoing test will give the answer and any further testing or experimenting is a personal matter with the examiner.

RECORD BLANK.

Examination with E. W. Scripture's Color Sense Tester No. ....

Place .... Date ....

Name of Examiner ....

Name of Person examined ....

Age .... Residence ....

Remarks ....

....

....

LEFT EYE. RIGHT EYE.

Left eye			Right eye		
A_1	J_2	G_3	A_1	J_2	G_3
B_1	K_2	H_3	B_1	K_2	H_3
C_1	L_2	I_3	C_1	L_2	I_3
D_1	A_2	J_3	D_1	A_2	J_3
E_1	B_2	K_3	E_1	B_2	K_3
F_1	C_2	L_3	F_1	C_2	L_3
G_1	D_2	A_3	G_1	D_2	A_3
H_1	E_2	B_3	H_1	E_2	B_3
I_1	F_2	C_3	I_1	F_2	C_3
J_1	G_2	D_3	J_1	G_2	D_3
K_1	H_2	E_3	K_1	H_2	E_3
L_1	I_2	F_3	L_1	I_2	F_3

The examiner must answer the following questions by "Yes" or "No."

1. Do the results of the tests with large openings indicate *safe* color vision for the left eye?.........for the right eye?.........

2. Does the test with the small opening indicate a central defect for the left eye?.........for the right eye? ....

Claims for the color sense tester.

1. The forms of color defect are so numerous and so various that a reliable test must be one that imitates the conditions found in the actual exercise of color vision. The color sense tester imitates these conditions closely.

2. This imitation of the practical conditions extends to the kind of object used, namely, colored lights under different conditions of brightness; to the kind of decision required, namely, the character of the light; to the kind of mental operation required, namely, a judgment after comparison.

3. The colored glasses are unchanged by use or time; the test is a constant one and needs no readjustment or renewal.

4. The performance of the test requires only a few minutes.

5. The instrument is portable and can be carried by the examiner in his pocket. Employees can be tested at any time on shipboard or on a train.

6. The test is absolutely automatic. The decisions of the person tested are recorded on the prepared blank in the spaces corresponding to the numbers on the revolving disc. A comparison of the results with a list of the actual colors will render the decision immediately. No call is made upon the intelligence or color vision of the examiner; it is only required that he shall record the answers honestly.

APPENDIX.

Forms of color vision.

It seems a well-established fact that most persons possess a color system in which any color can be considered as resulting from the union of three fundamental colors, red, green and blue. Such persons are called "trichromats."

If all trichomats possessed exactly the same vision of color, we could establish equations showing how much red, green and blue are required to produce any given color. It is a fact that, if we allow room for considerable variation, such equations can be established for a large portion of the trichromats. Such a group of persons might be said to possess a common "type" of color vision. By this we would not mean that the color vision was exactly alike in all cases but that they varied according to the usual laws of organic variation around a mean or average form of color vision. This type of color vision, which is that of the majority of human beings, is called "normal trichromasy."

As color vision is one of the properties of an organism, we may expect it to vary as other properties do. The fundamental principle of variation leads us to expect that among trichromats there will be individuals in whom the red, or the green, or the blue sensation is weaker than in the normal trichromats. Such individuals have been found ; they may be called " color weak trichromats."

I have had cases of this color weakness among my students. The first one I observed was absolutely perfect in passing the usual wool test but told me, after it was over, that when watching an approaching car carrying a red or a green light, he was unable to tell the color until it had approached within a block or two. When the wools were removed to a considerable distance away, he became completely confused and made judgments like a person in whom the green sensation was weak or lacking.

The cases are not so uncommon or so striking as would at first be supposed. Engineers have confessed—generally regarding some friend—that the wool tests have been passed by men who could not distinguish the signal lights in a fog. Some years ago several letters appeared on the subject in the London "Times" of which I quote a few.[1] One engineer made the following statement : "I have been on the railway for thirty years, and I can tell you the card tests and wool tests are not a bit of good. Why, sir, I had a mate that passed them all, but we had to pitch into another train over it. He couldn't tell a red from a green light at night in a bit of a fog." Another wrote : " To me the colored skeins of the wool test are no test at all, for both reds and greens in all shades are unmistakable ; and although I have undergone this examination whenever an opportunity has presented itself, I have never tripped. Close at hand, reds and greens are to me as to other people ; at a distance, however, my sense of color, in regard to red especially, is all astray. Standing on the edge of a large field glowing with poppies, I see them up to about thirty or forty yards as other people see them ; but beyond that distance they gradually merge into a neutral tint and become lost. . . . A distant red light over a chemist's door appears to be a dull yellow, and the same applies to a red railway signal." Another person writes, concerning his wife : "The red geraniums near my window she could see as well as I could ; but those a hundred yards off were lost in the green. She could choose and compare colored silks or worsteds, and could paint well, and was a remarkable good colorist." Such persons can be considered as cases of color-weakness.

In another type of color vision, known as " abnormal trichromasy "

[1] ELDRIDGE-GREEN, Color Blindness, 216, 217, 227, London 1891.

the red and blue fundamental sensations are apparently the same as those in normal trichromasy but the green sensation is of a different kind.

These abnormal trichromats seem to be quite common. They have been described by RAYLEIGH, DONDERS and KOENIG.[1]

I have for several years tested my classes in the following way; the origin of the test I have forgotten. A large red and a large green MAXWELL disc are placed in the usual fashion on the axle of a motor; a small black and a small white disc are then placed before the others. The room is darkened and a sodium light is produced by inserting salt (contained in a little platinum basket) in a BUNSEN flame. Both sets of discs appear in grayish yellow. Their proportions are changed until they match. About 70% to 80% of my pupils agree on one match and the rest on a different one. This would seem to indicate a rather large number of abnormal trichromats. It is difficult to make any statement concerning how the world appears to these abnormal trichromats beyond saying that is certainly quite different. KOENIG's measurements suggest that the preponderance of green is shoved toward the red end of the spectrum. We might infer that for such persons our reds and oranges are more yellow, our yellows more green and our greens more blue to them. This might lead to some understanding of peculiar colorings used by some artists.

The same principle of variation leads us to assume the existence of cases in which one of the fundamental sensations is entirely lacking. We thus would have "red blindness," "green blindness" and "blue blindness."

Cases of acquired color blindness are presumably of this form. The excessive use of tobacco and alcohol quite frequently produces color blindness. Accidents, such as severe falls and contusions, may also produce it. Cerebral troubles, over-strain of eyes, and other diseases sometimes result likewise.

In all such cases of acquired color defects we may readily assume the condition to arise by injury of the organ of one or more of the three fundamental colors; it is thus a true "color blindness" for one of the colors red, green or blue.

Many persons have been found for whom it was possible to produce all colors by mixtures of two fundamental colors, a "warm" color and a "cold" color. Such persons would be called "dichromats."

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[1] RAYLEIGH, *Experiments on colour*, Nature, 1881 XXV 67.

DONDERS, *Kleurvergelijkingen*, Onderzoek. i. Labor. d. Utrecht. Hoogesch. 1883 (3) VIII 170.

KOENIG UND DIETERICI, *Die Grundempfindungen u. ihre Intensitätsverteilung im Spektrum*, Zt. f. Psychol., 1893 IV 291.

Two distinct classes of dichromats are known; they are said to be "of the first class" and "of the second class."

The cold color of the dichromats is the same as the blue of the trichomats, the warm color is, in all probability, yellow, and not, as formerly supposed, either red or green.[1]

The two classes of dichromats differ only in the proportions of yellow found in any color of nature. The spectrum and all nature appear to them as systems of yellow, yellowish white, white, bluish white and blue; particular objects in the two systems differ only in yellowness or blueness. It is inconsistent with the facts to speak of "green blindness" and "red blindness"; the only safe way is to use the terms "dichromasy of the first class" and "dichromasy of the second class," as these will not imply a supposition that may prove incorrect.

It has been suggested that congenital dichromasy may be a phenomenon of atavism, or a return to the condition of color vision at a period in the ancestry of the animal kingdom when only two color sensations were present.

Still another form of color-vision is found in monochromasy. All the visible objects are seen as shades of one color. What this color is, it has as yet been impossible to say. In cases of congenital monochromasy it is undoubtedly not red, green or blue.[2]

We can also expect cases of "double color blindness" to arise from the failure of two of the fundamental sensations. Thus we would have red, or green, or blue monochromasy. Such forms of monochromasy may occur in pathological cases. Other cases of acquired monochromasy seem to follow still different types.[3]

The principles underlying these views of the nature of color defects can be more precisely stated in the following way.

If the amounts of red, green and blue be laid off on the rectangular axes, X, Y, Z, any color i will be given by

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[1] v. Hippel, *Ein Fall von einseitiger congenitaler Roth-Grünblindheit bei normalem Farbensinn des anderen Auges*, Archiv. f. Ophthalmologie, 1880 XXVI (2) 176; v. Hippel, *Ueber einseitige Farbenblindheit*, 1881 XXVII (3) 47.

Holmgren, *Flere Fall of ensidig Färgblindheit*, Upsala Läkaref. Förh., 1881 XVI 222. Also in Centralblatt f. d. med. Wiss., 1880, 898; Congrès internat. périodique des sciences méd., 8me Session, Copenhague, 1884; Ann. d'Oculiste, 1884 XCII 132.

Koenig und Dieterici, *Die Grundempfindungen u. ihre Intensitätsverteilung im Spectrum*, Zt. f. Psychol., 1893 IV 345.

Helmholtz, Physiologische Optik, 458, Hamburg und Leipzig, 1895.

[2] Koenig und Dieterici, *Die Grundempfindungen und ihre Intensitätsverteilung im Spektrum*, Zt. f. Psychol., 1893 IV 327.

[3] Koenig, *Ueber den Helligkeitswerth der Spektralfarben*, Beiträge z. Psychol. u. s. w., Helmholtz gewid., Hamburg, 1891.

$$i = f(x, y, z).$$

The assumption that the function is of the form

$$i = x + y + z,$$

is recommended by its simplicity. Such a color equation means that any actual color seen can be represented as a compound consisting of certain quantities x, y, z of the three fundamental sensations X, Y, Z. It also implies that the composition is a simple addition of the three fundamentals without an influence of one on the other. Although this apparently does not hold with exactness for some phenomena of color, yet is valid within wide limits with close approximation.[1]

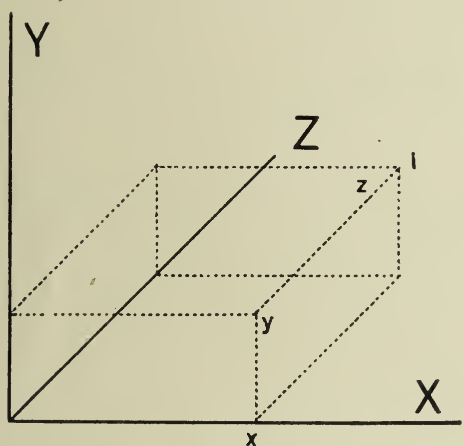

FIG. 5.

Such a color equation is represented in Fig. 5.

If r, g, b be taken as the strongest sensations of red, green and blue, obtainable in any person, the color-system for that person will be a pyramid whose base is rgb and whose apex is at the origin of coordinates (Fig. 6).

By supposing that $r' = g' = b'$ we have the right angle pyramid used by LAMBERT[2] to indicate the color-system. This supposition is, however, not a necessary one. In fact, the general character of our whole constitution would lead us to believe that an equality of this sort is not the usual case.

[1] HELMHOLTZ, Physiologische Optik, 376, 2 ed., Hamburg und Leipzig, 1896.

[2] LAMBERT, Farbenpyramide, Augsburg, 1772.

We can justifiably apply to color certain principles that have been found valid for the whole organism. One such principle is that of *variation.* We can, at the start, expect that any property common to a group of organisms will be found in various degrees in the various members of the group.

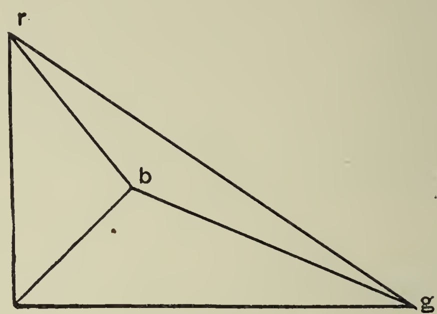

FIG. 6.

Applying this principle to color, we may say that a given series of colors i_1, i_2, $\cdots$, i_n derived from the equations $i_1 = x_1 + y_1 + z_1$, $i_2 = x_2 + y_2 + z_2$, $\cdots$ for one type of color vision might require slightly different equations for various individuals. Thus the same colors i_1, i_2, $\cdots$, i_n might require the equations $i_1 = x_1' + y_1' + z_1'$, $i_2 = x_2' + y_2' + z_2'$, $\cdots$, for a second kind of vision; $i_1 = x_1'' + y_1'' + z_1''$, $i_2 = x_2'' + y_2'' + z_2''$, $\cdots$, for a third kind, etc. We might consider the type $i = x + y + z$ as the standard and express the varying individuals in terms of it by equations of the form $i = \alpha x + \beta y + \gamma z$ where α, β, γ are coefficients changing for each individual.

The individual sets of values for α, β, γ may group themselves around various most frequent values and may represent types of color vision. We may say that $\alpha = \beta = \gamma = 1$ is the expression for the normal type for which the equation is $i = x + y + z$. Any other group of individuals whose equations are similar enough to furnish a typical form may be classed as an abnormal type. All persons belonging to abnormal types might be called "color defectives."

The fundamental principle of variation leads us to assume a type in which α is much less than β and γ. This gives an equation of the form $i = \alpha' x + \beta y + \gamma z$ in which $\alpha' < \beta = \gamma$. The equations $i = \alpha x + \beta' y + \gamma z$ and $i = \alpha x + \beta y + \gamma' z$ would arise likewise for analogous types. These would be the equations of persons who have been called "color weak."

When the variation is so great that α, β or γ become 0, there arise cases of what is properly called "color blindness." Such persons might be characterized as "red blind" with the equation $i = \beta y + \gamma z$, "green blind" with the equation $i = \alpha x + \gamma z$, and "blue blind" with the equation $i = \alpha x + \beta y$.

Other types of variations of α, β, γ may occur but no data yet exist for stating the facts.

It is also quite possible that the three fundamental sensations may not be the same in all persons. In one class of persons already discovered the fundamental green sensation is different from that of the majority; such "abnormal trichromats" would have equations of the form $i = x + v + z$. The analogous types of abnormality like $i = u + y + z$ and $i = x + y + w$ and also the subordinate types probably also exist but have not been discovered.

The two forms of dichromasy are characterized by equations of the forms $i = w_1 + z$ and $i = w_2 + z$. These also are to be considered only as typical forms from which the individuals vary just as in the cases of trichromasy.

Typical monochromasy is indicated by $i = p$ while the possible cases of double color blindness, or red, green or blue monochromasy, would be expressed by $i = x$, $i = y$ and $i = z$.

In conclusion we may repeat that the forms of color vision are merely types of groups of individuals, that the members of a group vary from the type and that more extended examination of unusual cases would probably show most of the intermediate steps between the typical forms.

In the midst of such diversites in the types of color defect it would be hardly safe to base any test on the supposition that the prevailing defect is of any one or two types. To suppose that all essentially important cases of defect belong to the two types of dichromasy known as the first and the second would be a neglect of somewhat numerous other types. Such a supposition is used as the basis for the HOLMGREN wool test; it is evident that the various forms of "color weakness" and the like are not provided for. Furthermore, the HOLMGREN test is based on the additional supposition that the two forms of dichromasy are "green blindness" and "red blindness"—a supposition that is unquestionably unjustifiable.

Under these circumstances the only safe method of procedure in selecting a test seems to lie in avoiding all suppositions while making the test conform as closely as possible to the conditions of actual practice.